BLIND READER: An Intelligent Assistant for Blind

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***Abstract*— In the real world, books and documents are the sources of knowledge. But this knowledge is only bounded to people with clear vision. Our society includes a group of people who does not have a clear vision or people who are blind. For this group, world is like a black illusion. The shape and structure's information of an object is unavailable to them let alone reading a document. For blind acquiring knowledge by reading documents is cumbersome. Braille is one of the methods which is used to read a book or document. In this method, any document has to be converted to braille format to become understandable to a blind. The problem arises due to the fact that, this is an expensive procedure and many times not available. The solution is rather simple, introduce a smart device with a multimodal system that can convert any document to the interpreted form to a blind. A blind can read document only by tapping words which is then audibly presented through text to speech engine. "Blind Reader" – developed for touch devices which is user friendly and effective interactive system for visionless or low vision people.**

Keywords—blind; low vision; visually impaired; braille; screen reader; braille printer; screen magnifier; smart reader; dynamic scroll; haptic; touch;

I. INTRODUCTION

In our world information is generally available in the form of books and documents. It is fully usable for the sighted people. From an ancient time, information is resembled in aural format as no other representation of it is founded in printing format. When an era has come of printing it facilitates the sighted people partially to acquire knowledge. A major problem for a blind or visually impaired person (BVI) to interact with the world to share knowledge. For them information has to be in a special tactile language or in voice format. About 20 million people in USA live with visual impairments [2]. They are affected in every works of their daily life. Nowadays technology helps them to overcome this difficulty to some extent. Many hardware or software tools are invented to help them [1]. The most difficult task for them is reading text from the books or documents.

For the blind or visual impaired (BVI) person, it is a very difficult job to acquire information from the world. One feasible way in order to perform that job is that someone will help him to read aloud the context. Another way to get the information is by giving a feelings of the information. The later technique is built through a representation of the information on a paper or a substantial surface so that a blind person can feel and recognize the information. But it is a very difficult work to make all the books or documents available for the blind people. It needs a large amount of papers and employments to make it tangible so that a good number of blind persons get access to the global information system. Now a days a smart technology is adapted to help the blind. An application is developed that read aloud the context of the document which is represented virtually. This later technique reduces the resources to help the blind to acquire knowledge but in this manner he can be assisted only audibly. He does not have any haptic feelings of information. To meet the challenge to acquire knowledge through a haptic method an effective method is designed. In this method, a blind person can get a tactile feelings of the information on a screen of a smart phone. He can use his fingers to move around the screen over a virtual document and get the information audibly. In this case, he gets the access to all the information of the world as most of it is stored virtually. Besides it is a human cognizable method through which human can interact with the system to acquire knowledge.

In Section II, the related works are described. Sections III contains our proposed solution. In Section IV, the system overview is described. Section V contains system functionalities and Section VI shows evaluation and test analysis of the system. Section VII discusses about the future scope and Section VIII is the conclusion.

II. RELATED WORKS

There are some technical systems which are emerged nowadays to help the visually impaired persons. To introduce them, the first which can come in our mind is '**Braille**'. It is a system that uses 6 raised dots in 2X3 fashion per cell to represent a symbol. This symbol may be a character of any language, a punctuation, or any other indicator which carries a meaning. These dots are sensed with the finger (generally an index finger) to gain the information from this pattern. The right column is numbered from 1-3 and the rest is from 4-6. There will be 64 (2^6) possible different kinds of patterns from per cell. But it does not represent a different language from our native ones. This is actually a representation or encoding from our known native language such as English, Arabic, Spanish, Bengali and so on. Each dot pattern represents a letter of any language including punctuation, symbols and so on. If only one cell is not sufficient for representing a symbol of any language then multi-cell is used. To allow a multi-cell pattern we have to use another special cell to make it recognizable. There are different kinds of Braille used by the BVI. In grade-1 type of Braille, it represents only one letter, number, punctuation sign, or special Braille composition sign per cell. It is actually a one-to-one conversation. No abbreviation or word is permitted here. Grade-2 type braille is the advanced version of grade-1. It permits words and abbreviation and thus saves space in printings. A system of styles or rules is developed for this grade. In grade-3 type, it uses an unstandardized shorthand format which is not used in publications [3, 4].

Another technology that is used to help BVI is **Screen Reader.** It reads the text aloud which is displayed on the screen or monitor of a computer, mobile, tablet or other devices having screen or monitor. It uses refreshable braille display or a text-to-speech synthesizer to make the text audible. It works closely with the operating system to get the information from the screen or monitor and sends the feedback to the speaker of the computer system. In this technology, a text-to-speech engine software is embedded with the screen reader or a hardware facility is provided to make it operational. It can also provide information from a digital braille system using a refreshable braille display [5, 6].

The next technology which is beneficial to the BVI is **Finger Reader**. It is a wearable device in finger. It helps the BVI to access the plain printed text. People who ware this device, scan a text line with their finger and in a result they get an audio feedback of the words and also a haptic sense of the layout. These senses may be the start or end of the line, new line and so on. It also alerts the reader if he moves away from the baseline thus it helps him maintain straight scanning. [7]

A common device nowadays that helps the BVI technically in their daily chores is **Braille Notetaker** which replaces ordinary standard QWERTY keyboards to give input to the computer. It also uses text-to-speech synthesizer and sometimes refreshable braille display for output to the BVI from regular screen. [8]

Braille Printer is a kind of embosser which is a technical hardware that can print the hardcopy of braille. To perform that job it uses the braille translation software program which can convert the electronic text from the computer device to braille. It uses heavyweight papers to print the braille on both side. It is much slower, nosier and more expensive process. [9]

Screen Magnifier is a computer graphical output that represents the enlarged form of the screened context. It is actually used for improvement of the visibility and computing power for them who are weak in visibility. [10]

Another pc assistant to read the text aloud from the screen to the BVI is the **E-Book Reader or Audiobook Reader.** It reads the e-book which are appeared on the screen with a push button or touch screen gesture facilities. It also uses the text-to-speech function to perform this job. It is very popular for its portability and availability. [15]

A technical work which is also in research is a system where a BVI moves his fingers on the electronic text document on touch screen device and this touched word is read aloud. A framework of tactile landmarks helps the BVI to navigate a page showed on the display of the device. [11]

In this paper, we also develop a system that highlights the functionalities described in the last method [11] with some extra features to make the job more operational and flexible for the BVI. The solution is very efficient than any of the aforementioned research work. The designed system is very much user friendly to the visually impaired people.

III. PROPOSED METHODOLOGY

Blind Reader is a modified reader which helps visually impaired people to read a document. The reader has special mechanism to interpret the reading materials using haptic technology (the perception and manipulation of objects using the senses of touch). Generally, people who are blind or visually impaired live in a world without images. For people with sight, the sense of vision is the primary means for assessing and interpreting clues in the external environment. As the images are transferred to the brain, people react both physically and emotionally. Without sight secondary senses evolve into the medium of assessing the external environment. Therefore, blind people learn to adapt and hone their remaining senses to allow for largely independent living in a society that sees. Blind Reader converts the sense of touch into audible power and thus helps the reader to understand the words they are touching. As a result, it can create the touch and feel perception which was absent previously. A visually impaired person touches a word which is then interpreted through voice feedback from the system and helps the person to asses only by using the hearing power.

Our proposed solution is an assistant for a blind to read electronic documents. It not only creates the sense of touch and hearing but also helps a reader to understand and go through the materials effectively. Blind Reader is an app that is designed for android handheld devices. The interface is developed in a way so that a blind can easily access the options provided by this app. The solution is very simplified based on the reading materials only. Touch sense works on horizontal line in the mobile screen. A person can touch and move his finger tip horizontally from left to right on the mobile screen just like reading a book. The words those are touched are read out though voice feedback from the system. The system considers the whole documents as a collection of words. As a result, it can clearly distinguish the accurate word that is touched by a user. In our case as the user is visually impaired, many information on the screen will not be visible by them. Alongside, the complexity remains as a blind person cannot interpret actions in the interface. However, to compensate with the complications, the touch types and touch durations time is mapped into different actions. Such as, if a user single tap on the word the word is read out, but if he uses double tap on a word the line number containing the word is read out. Again, a shorter tap on any option in the setting panel result in trigger whereas, a longer tap results in voice feedback about that option.

There are many traditional screen readers [5, 6] are available in the market but none of them is capable to give user the touch and feel perception. Our approach is more likely reading a real book. A person can read the same line again and again until he can get the meaning. This can give a blind person the feeling of real world, when he is dealing with electronic documents.

Again Braille is not available sometimes and can be expensive as well. Our system is inexpensive and available for any documents. The documents those are available in soft copy can be converted into a collection of words and interpreted through touch and feel method with voice feedback using this system.

IV. SYSTEM OVERVIEW

According the proposed method, in our research we used a static touch capable display (i.e., Android smart phone), which can be used as a tactile landmark for navigating the screen. A text document is opened through this display in customized pdf format and can be mapped spatially. From text document, which word is selected with the finger touch can be transformed to an audible format using text-to-speech synthesizer. It gives a model that gives a sense of reading a book through touching and hearing. The system architecture can be interpreted from the following flow chart:

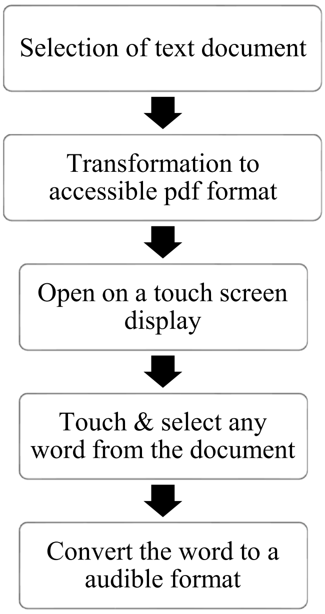

Figure 1: System Architecture

To use Blind Reader, a user has to browse and select any file that is in the .docx, .pptx or .pdf format. After selection, the preferred file is converted into .pdf format and the texts of that file are reconstructed as a collection of words and presented in an interface. Pictorial information or images are filtered out. Moreover, the text size resized to an optimum form for the easy interaction of blind user.

Figure 2 shows the reconstruction of the selected document. It is also necessary to transform the selected pdf file to an accessible format known as “tagged pdf”. This is important due to the fact that; the words must be accessible to the finger touch on the display. After tagging the text document, each word in it can be accessible. In addition, to read any document in the interface e.g., Figure 2, a user has to touch to select a word from the interface. This touch can be described as motion event, such as: action down, action up, action move and so on. These actions present the change of states according to the pointer’s movement. Using the text-to-speech (TTS) engine (also known

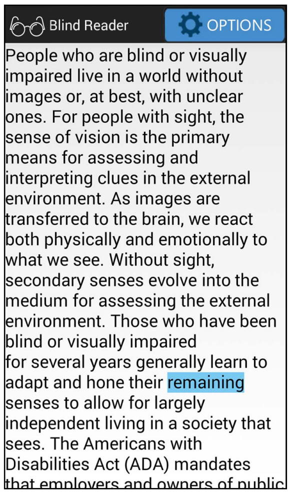

Figure 2: Reconstruction of texts in the interface

as speech synthesis), it enables the device to speak the text or specifically the word that is being touched. Again, if a blind user mistakenly avoided a line and break the sequence of reading (user was reading the first line after that user tap to the third line which causes missing of second line) the device will notify the user by vibration alert. Figure 3 shows the vibration event due to breaking line sequence.

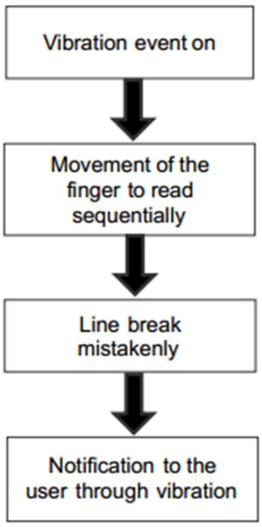

Figure 3: Vibration Alert

Again user can also track the line number by double tapping on a single word. Double tap triggers the voice feedback, saying the line number in which the word resides. This helps the user to keep track of the document and also prevent them from erroneous reading. There are also smart features like vibration alert (i.e., to notify line sequence break while reading showing in figure 3), dynamic scrolling (i.e., scrolling the document by tilting the device upward and downward) to make the interaction very much effective.

V. System Functionalities

The system can be viewed from three major parts. Those are: (1) The interface design, (2) Voice feedback and (3) Smart features.

A. *Interface Design:*

As we are dealing with visually disabled people, the interface should not be focused on graphical effects rather it should be concerned with perceptible information that is easily accessible and interpretable. Different design guidelines in designing interface [12, 13] are available to help a blind user. The one of the most important challenges of designing such interface is the placement of buttons and options. In a screen, if the buttons are placed in an isolated manner the concerned user will be unable to find it. As a result, their actions cannot be performed by that interface. The solution is simple and straight forward: placing the buttons in a place in the interface that can be easily traceable by the user. Figure 4 shows our designed interface.

Figure 4: Interface Design

From figure 4 it can be seen that, the three buttons named as: “Options”, “Close”, “Browse” are placed only in the edges of the interface. In addition, the most easily perceptible areas on a screen are the edges. In an electronic device such as phone, tablet, computer screen, there are four edges. The buttons are placed in only three out of the four edges in our design.

B. *Voice Feedback:*

Voice feedback is the only notification that can be perceptible by a blind user. In our work we have introduced voice feedback with every successful touch. As for example, if a user touches a button such as Options (upper right of Figure 4), a voice feedback: “Showing Options” is generated and read out by the system. This will trigger another interface that is shown in Figure 5. Again, the duration of touch triggers different functionalities. If any user taps on a button, it will trigger the selection of that button or option. On the other hand, if any user uses longer tap on a button or option than a voice feedback is generated e.g., if any user longer taps on “browse” then the system will give audible feedback saying “browse”. Special buttons like “Dynamic Scroll”, “Line check”, “Auto Read” are associated with on or off status. Longer tap on these buttons also triggers the status feedback. As for example, if a user uses longer tap on Dynamic Scroll option (Figure 5) the system audible feedback will be: “Dynamic Scroll, Current Status on”. Furthermore, if any user wants to change the status or wants to select any option, he has to use single tap.

Figure 5: Provided Options and Voice Feedback

C. *Smart Features:*

Smart features are introduced in order to make the effective interaction with the user. Blind user may be misguided while reading a document. The erroneous reading or missing line sequence creates adverse effect on system interaction. To compensate with certain problems tracking line number is introduced. Our system automatically tracks each and every line that has been read by the user so that it can suggest the next line that should be read. Option “Line Check” (from Figure 5) helps the user by triggering vibration alert if a line sequence is broken. Therefore, if a user gets vibration alert, he can move back to the correct line. Again line number can be known by double tapping on a line.

Another problem in this kind of interaction is scrolling. A blind person is unable to scroll through a document. In solution, we have introduced “Dynamic Scrolling” (from Figure 5) which uses the gyroscope sensor of a device. When any device is kept horizontally (up to 30 degree) to the ground, our system considers this as a reading mode. Reading mode acts like normal interaction, allow the user to read the page. But when the device is tilted downward (more than 30 degree), the system triggers scrolling down. Therefore, the document that the user is reading can be scrolled down by tilting down (in Figure 6) the device. Similarly, the document can be scrolled up by tilting the device (more than 30 degree) upward.

Figure 6: Tilting down device

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This arise another problem that a blind user will be unable to know if a document is scrolling or not. The solution of this problem is letting the user know about the scrolling information. In our case, as a blind user is already familiar with the line number from the system, the information of the line number is enough to let the user know about the scrolling. Therefore, we used audible feedback of line number. After each 5 line of scrolling the system automatically speaks out the line number that let the user know, which line has already been scrolled. Figure 7 shows the dynamic scrolling mechanism.

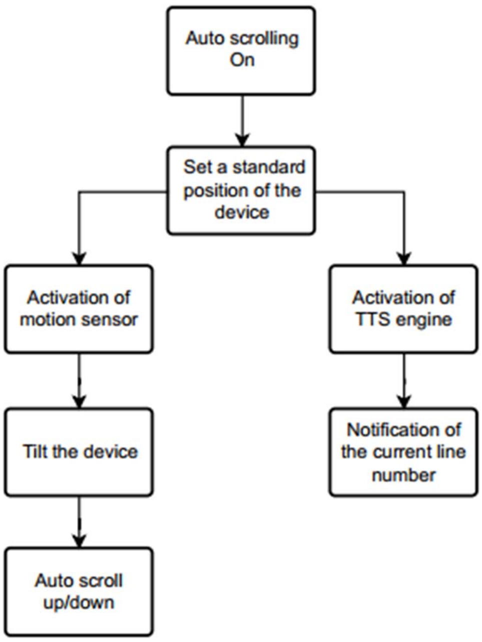

Figure 7: Dynamic Scrolling Trigger

VI. EVALUAION AND RESULT ANALYSIS

For the evaluation, we took 11 BVIs who are students of Masters from University of Dhaka (DU) to take the feedback using our system comparing with other methods on the matrices of time, error rate, mental and physical workload and task difficulty according to NASA Task Load Index [14]. The students are from the department of Special Education of the Institute of Education and Research (IER). We gave them few tasks. The tasks were the followings:

1. Read a document of 100 words using braille, screen reader as well as using our system.
2. Read a large document (500 words) using braille, screen reader and our system and then answering some questions.

From the first task the feedback we got was outstanding. The users were only allowed to read the document once without any interruption. We took the time as matric to check the efficient interaction. The average results from 11 users were considered. From the findings of the results we noticed that screen reader performed well in case of task 1. But in case task 2, which depicts the understanding of a document, screen reader performed worst.

Figure 8 shows the results we found from task 1. The average time taken to read a 100 words document using braille is 112 second (1 min 52 sec), using screen reader is 58 second and using proposed system is 66 second (1 min 6 sec).

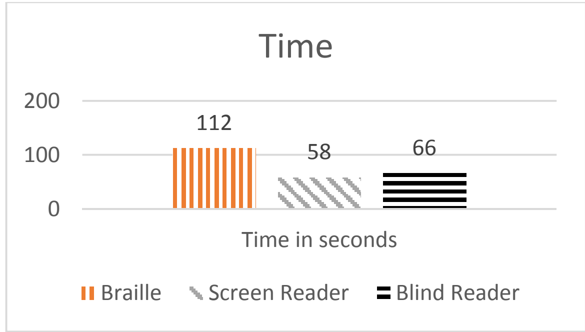

Figure 8: Time comparison of task 1

For task 2 after reading a large document we asked 10 questions to every user to check the understanding of the context they read. The analysis was made based on the feedback of the answers. We took the correctness percentage of the questionnaires. Figure 9 shows the context evaluation result. We found that the percentage of correctness of braille is 72%, of screen reader 46% and of proposed system is 80%.

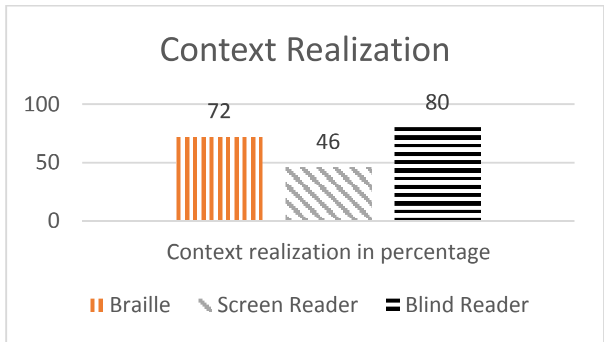

Figure 9: Context Realization (task 2)

Therefore, our proposed system may take long to read a document but it can be the best solution for understanding the context of a document.

Again, we told them to use our system for seven days. We took the interview of users to know about their satisfaction level after their usage. The feedback was very much appreciable. They were having complications with using the system at first. But after using it for a few days they were accustomed to the system. They were very much interested and wanted the system in the play store for mass usage.

VII. DISCUSSION AND FUTURE SCOPE

The interview session pointed out some of the requirements the user made. The users also intended to have a solution to read the Bengali text that are unavailable now. They also claimed for extra features to make it more functional and returned positive appreciation. Currently there is no solution to interpret any graphical or pictorial image to a blind user. Most of the higher study books are unavailable in braille format. So they needed a solution as soon as possible. At present they are using well known "screen reader" application for their higher study but for repetition of any context for better realization they do all the cumbersome work. On the other hand, for braille they go through the braille more than 2 or 3 times. But for our proposed system they need not repeat the whole context like screen reader or the braille sentence. They can easily come back to previous line as the system aid them to go through. The future work is to deal with Bengali context and making it really cognitive for better understanding.

VIII. CONCLUSION

In the world, 4.25% people are blind or visually impaired (BVI) from which 14% people are blind [2]. Our research is focused on the developing a system that reduces the difficulty of reading a document and also introducing a cognitive system that can give the blind people a sense of haptic feeling. Blind Reader, an android application is a cost effective solution that can convert any document (.docx, .pptx, .pdf) to accessible form to a BVI. This gives the BVI a total mental concept of reading context. The satisfaction of the user of this system is tremendous. Therefore, this can be the ultimate solution of an effective interaction for a BVI.

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